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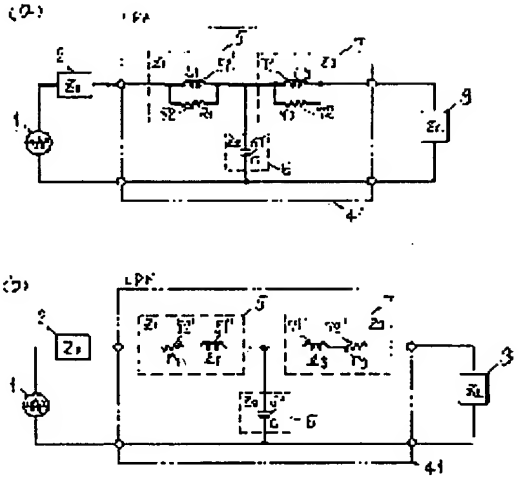
(54) LOW PASS FILTER FOR POWER LINE CARRIER COMMUNICATION

(57)Abstract:
PURPOSE: To obtain the low pass filter at a low cost in which a sufficient suppression ratio is ensured in general without matching of an impedance of a power line fluctuated unstably and a power supply for a noise production device for power line carrier communication for a home automation system or the like, effective to impulse noise or the like with high productivity.
CONSTITUTION: High impedance elements 5, 7 are formed by parallel connection circuits comprising coils 51, 71 and resistors 52, 72 having the equal resistance to the impedance of the coils 51, 71 at an object frequency to be blocked and the sufficient equivalent series resistance component is devised to remain even when the impedance is mismatched. Moreover, a capacitor 61 having a capacitance whose resonance frequency is sufficiently lower than the object frequency is connected to the parallel circuit to prevent the conversion into a disturbing frequency such as impulse noise frequency and the entire circuit is formed to be non-resonant, the selection and adjustment for components for the resonance are not required, the productivity is improved and the cost reduction is realized.



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The piece or two or more high impedance components by which series connection was carried out mutually which serve as a high impedance in the purpose frequency which was inserted in the serial at one side of a power-source line, and which should be oppressed, It has the low impedance component which serves as low impedance in the purpose frequency between the end of a high impedance component or the connection middle point, and another side of a power-source line. Said each high impedance component The low pass filter for power line carrier communication constituted from a parallel connection circuit with resistance with resistance equal to the impedance value of a coil and said coil in the purpose frequency.
[Claim 2] The low pass filter for power line carrier communication according to claim 1 which constituted the low impedance component only from a capacitor, and set up the capacity of a capacitor so that each resonance frequency by a part for each equivalence serial inductance and the capacitor of the parallel circuit by the coil of each high impedance component and resistance might serve as a value lower enough than the purpose frequency which should be oppressed.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention makes the power line a signal-transmission way, and relates to low pass filters for power line carrier communication, such as home automation which communicates using a RF carrier.
[0002]
[Description of the Prior Art] In the home automation system by the power-line-carrier-communication method, as shown in drawing 5 , there are two kinds of applications of a low pass filter (it omits Following LPF). One is the blocking filter (it omits Following BF) 130 which prevents leakage ** outside of the signal transmission between a controller 150 and an adapter 160, and another is the noise filter (it omits Following NF) 140 which stops device noises, such as home electronics connected to the power line 120.
[0003] As a technique common to these LPF is shown in drawing 6 (a), (b), and (c) Each of the internal components 5 (Z1), 6 (Z2), and 7 (Z3) of LPF 47, 48, and 49 It consists of juxtaposition or the series resonant circuits of the coils 55, 65, and 75 and capacitors 56, 66, and 76 which resonate on the purpose frequency which should be prevented. While preventing oppressing the purpose frequency component of the noise of a terminal a noise-source side (left-hand side) in drawing 6 (c), and appearing in a power-source line side (right-hand side) terminal, the impedance (it omits Following imp) of a power-source line side is raised by the high impedance component 7. At drawing 6 (b), it prevents signal transmission appearing in a power-source line side (right-hand side), while raising imp of a terminal the source side of a signal (left-hand side) by the high impedance component 5, and by drawing 6 (a), while the configuration of a T character mold raises the power-source line side imp, the oppression ratio of a noise is improved. At this time, a signal or the oppression ratio of a noise is [0004].
[Equation 1]

$$\frac{V_L}{V_0} = \left| \frac{Z_2 Z_L}{(Z_0+Z_1)(Z_2+Z_3+Z_L)+Z_2(Z_3+Z_L)} \right|$$

または、

$$\frac{V_L}{V_0} = \left| \frac{Z_2 Z_L}{(Z_0+Z_1+Z_2)(Z_3+Z_L)+(Z_0+Z_1)Z_2} \right|$$

[0005] It is come out and expressed.
[0006]
[Problem(s) to be Solved by the Invention] Generally, the line intercadence force imp of power supply sections, such as a household-electric-appliances device connected to the power line, is impossible for performing unspecified, and LPF which Rhine imp of the power line (ZL) becomes unfixed, and inserts it there since time variation is carried out and imp adjustment.

[0007] Moreover, since the high current of low frequency flows for the high imp components 5 and 7 generally [drawing 6] constituted using the coil containing a magnetic core, the inductance of a coil will decrease by the magnetic saturation of a magnetic core, and the resonance point will shift.
[0008] Furthermore, although perfect resistance is shown if the input frequency of the parallel resonant circuit of a coil and a capacitor is the same as resonance frequency as shown in drawing 7 , when the resonance point shifts, even if the resonance point is a nearby frequency very much, a change large to capacitive [smaller than the capacitor simple substance from inductivity with the bigger imp than a coil simple substance] will be shown, and series resonance will be carried out as simply as all external imp(s).
[0009] Therefore, the high imp component 5, the source of a signal, or noise source imp2 from which the resonance point shifted carries out series resonance, the high imp component 7 and power-source Rhine imp3 carry out series resonance similarly by the minute resistance r1, and only the amount of [r3] minute resistance may not remain respectively.
[0010] Then, said oppression ratio is [0011].
[Equation 2]

$$\frac{V_L}{V_0}=\left|\frac{Z_2\,Z_L}{Z_2(r_1+r_3)+r_1r_3}\right|\fallingdotseq\left|\frac{Z_L}{r_1+r_3}\right|$$

$$\left(\begin{array}{l}|Z_L|>1,\\ r_1\ r_2\ll 1\end{array}\Rightarrow\frac{V_L}{V_0}>1\right)$$

[0012] about [being invalid as a next door and LPF] -- being even harmful -- it is. Furthermore, since the low imp component 6 constitutes the series resonant circuit and it is emitted by free vibration although it saves high frequency by forced oscillation, changes it into the frequency which should be prevented essentially that impulse noise etc. should be what kind of frequency and is minute level, this [its] is not desirable as LPF, either.
[0013] Moreover, the configuration of the resonance circuit by the coil and the capacitor needed sorting of components, and adjustment of the resonance point in the production process, and had caused the fall of productivity, and the rise of cost.
[0014] The productivity which is not based on external imp conditions but secures an oppression ratio sets it as the first purpose to offer LPF of low cost highly, and this invention sets it as the second purpose to offer LPF to which the frequency-conversion operation by shifting to free vibration from forced oscillation does not take place.
[0015]
[Means for Solving the Problem] For solution of said technical problem, the low pass filter for power line carrier communication of this invention By constituting a high imp component as the first means by the parallel connection circuit with resistance equal to the imp value in the purpose frequency of a coil and a coil The second purpose is attained by attaining the first purpose and using a low imp component as the capacitor of capacity by which resonance frequency with the equivalence serial inductance of a high imp component becomes lower enough than the purpose frequency as the second means further.
[0016]
[Function] The parallel connection circuit with resistance of a value with a high imp component equal to the imp value of a coil and the coil in the purpose frequency which should be oppressed according to the first means of this invention is [0017].
[Equation 3]

$$R/\!/j\omega L=r+j\omega\ell\quad(\omega=2\pi f)$$

$$r=\frac{R(\omega L)^2}{R^2+(\omega L)^2},\quad \omega\ell=\frac{R^2\omega L}{R^2+(\omega L)^2}$$

[0018] It is alike and becomes a series circuit with resistance of a half value as well as the inductance of the value of the one half of the original value equivalent by the parallel serial conversion which follows. Since the amount of resistance strong enough remains even if lost by the amount of

inductance by the series resonance by a source of a signal or a noise source imp which was explained in the conventional example, or power-source Rhine imp Since r1 and r3 in several 2 are not minute, and they are enough more greatly [than the low imp component Z2] equivalent to power-source Rhine impZL or it becomes a larger value than it, an oppression ratio is [0019].

[Equation 4]

$$\frac{V_L}{V_O} = \left| \frac{Z_2 Z_L}{Z_2(r_1 + r_3) + r_1 r_3} \right|$$

$$(r_1,\ r_3 \geqq |Z_L| \gg |Z_2| \Rightarrow \frac{V_L}{V_O} \ll 1)$$

[0020] A next door and sufficient oppression ratio are secured. Moreover, sorting and adjustment of the components for the resonance needed conventionally become unnecessary, and the external imp conditions of not becoming capacitive absolutely since Z1 and Z3 do not constitute the resonance circuit, therefore starting these and series resonance can attain improvement and low-cost-izing of productivity while becoming only a capacitor, the probability of series resonance itself decreasing and they being able to secure still more sufficient oppression ratio.

[0021] since according to the second means it have set up so that it may become lower enough than the purpose frequency in which it be the non-series resonance mold which constituted the low imp component Z2 of the first means only from a capacitor , and resonance frequency with the equivalence serial inductance of the high imp component of order should oppress the capacity value , the frequency conversion operation by shift to free vibration from forced oscillation take place neither on the purpose frequency nor the frequency of the neighborhood , but the engine performance as LPF be secure .

[0022] Moreover, since it is circuitry of a dissonance mold, sorting and tuning of the components for resonating a low imp component become unnecessary, and improvement in productivity and reduction of cost can be aimed at.

[0023]

[Example] The first example of the first means of this invention is shown in drawing 1 .

[0024] LPF of drawing 1 (a) is the T character mold filter which consists of a low imp component 6 (Z2) connected between two high imp components 5 (Z1) and 7 (Z3) by which series connection was carried out to one side of the power line, the middle point of those, and another side of the power line. The high imp components 5 and 7 are the parallel connection circuits of a coil 51, resistance 52, and a coil 71 and resistance 72 respectively, and a parallel serial conversion is carried out by the transformation of (several 3) like drawing 1 (b).

[0025] Here, the conditions from which the engine performance of this LPF becomes the minimum are the cases where equivalence serial inductance 51' (l1) and 71' (l3) carry out series resonance to the source of a signal or a noise source imp2, and power-source Rhine imp3 respectively in the purpose frequency which should be oppressed.

[0026] At this time, it becomes Z0+Z1=r1 and Z3+ZL=r3, and an oppression ratio takes the minimum value expressed with (several 4).

[0027] for example, on the frequency of 125kHz generally used for power line carrier communication as what is about ZL=10ohm and does not ask the configuration of the low imp component 6 -- Z2=0.2ohm and omegaL1= 40-ohm(angular-frequency omega =2pif) omegaL, since about 3= 40ohms is obtained easily If it is made R1=40ohm and R3=40ohm, equivalent, r1=20ohm and r3=20ohm can be secured, and, as for the oppression ratio at this time, the 46dB of the minimum abbreviation will be guaranteed.

[0028] Moreover, since it is not a resonance mold with the configuration of such a high imp component, even if an inductance value changes with the load currents which flow a coil somewhat, there is no big effect in the property of LPF. For example, even if an inductance value is halved, it is confirmed that the whole oppression ratio remains in 1dB aggravation. Therefore, strict sorting and adjustment of a coil or resistance are unnecessary, and the remarkable improvement in productivity and the reduction of cost of them are attained.

[0029] The second example of the first means of this invention is shown in drawing 2 . LPF42 of drawing 2 (a) is the inverted-L-shaped filter which consists of a low imp component 6 (Z2) connected between the power-source line side of the high imp component 5 (Z1) and the high imp component 5 connected to one side of the power line, and another side of the power line. The high imp component 5 functions as a BF for raising imp by the side of the source of a signal while being the parallel connection circuit of a coil 51 (L1) and resistance 52 (R1) and making it signal transmission not leak to a power-source line side, and a parallel serial conversion is carried out by the transformation of (several 3) like drawing 2 (b). In this case, since LPF42 does not need to raise imp of a power-source line side, the high imp component of a power-source line side with fear of power-source Rhine imp3 and resonance has been deleted.

[0030] The principle of operation is the same as that of the first example of the first means, and the minimum oppression ratio is [0031].

[Equation 5]

$$\frac{V_L}{V_O}=\left|\frac{\dfrac{Z_2 Z_L}{Z_2+Z_L}}{r_1+\dfrac{Z_2 Z_L}{Z_2+Z_L}}\right|=\left|\frac{(Z_2 /\!/ Z_L)}{r_1+(Z_2 /\!/ Z_L)}\right|$$

$$(r_1 \gg |Z_2 /\!/ Z_L| \Rightarrow \frac{V_L}{V_O} \ll 1)$$

[0032] It is alike and follows. For example, ZL = if about 10 ohms, omegaL1=40ohm, R1=40ohm, and Z2=0.2ohm, it is set to r1=20ohm and the minimum oppression ratio can secure about 40dB.

[0033] Moreover, since there is no high imp component of a power-source line side, miniaturization and low cost-ization can be attained.

[0034] In addition, other descriptions by being a dissonance mold are the same as the first example of the first means.

[0035] The third example of the first means of this invention is shown in drawing 3 . LPF43 of drawing 3 (a) is the inverted-L-shaped filter which consists of a low imp component 6 (Z2) connected between another side of the power line the noise-source side of the high imp component 7 (Z3) connected to one side of the power line, and the high imp component 7. While the high imp component 7 is the parallel connection circuit of a coil 71 (L3) and resistance 72 (R3) and raising imp of a power-source line side When a noise source imp2 is large enough, using that, a noise functions as NF it is made not to leak to a power-source line side, and a parallel serial conversion is carried out by the transformation of (several 3) like drawing 3 (b).

[0036] In this case, since LPF43 does not need to raise imp by the side of a noise source, the high imp component by the side of a noise source with a possibility of resonating with a noise source imp2 has been deleted.

[0037] The principle of operation is the same as that of the first example of the first means, and the minimum oppression ratio is [0038].

[Equation 6]

$$\frac{V_L}{V_O}=\left|\frac{Z_2 Z_L}{r_3(Z_O+Z_2)+Z_O Z_2}\right|$$

$$\left(r_3,\ Z_O \geq Z_L \gg Z_2 \Rightarrow \frac{V_L}{V_O} \fallingdotseq \left|\frac{Z_2 Z_L}{Z_O r_3}\right| \ll 1\right)$$

[0039] It is alike and follows. for example, Z -- 0 = about 20 ohms and ZL= -- about 10 ohms and omegaL -- if 3= 40 ohms R 3= 40 ohms Z 2= 0.2 ohms, it is set to r3=20ohm and the minimum oppression ratio can secure about 46dB.

[0040] Moreover, since there is no high imp component by the side of a load, miniaturization and low cost-ization can be attained. In addition, other descriptions by being a dissonance mold are the same as the first example of the first means.

[0041] Furthermore, as an example of the second means of this invention, as drawing 1 , drawing 2 , and the low imp component of drawing 3 are beforehand shown in each drawing By setting up so that it may become lower enough than the purpose frequency in which resonance frequency with the equivalence serial inductances 51 or 71 of the high imp components 5 or 7 should oppress the value while considering as the configuration of only a capacitor 61 The frequency-conversion operation accompanying the shift to free vibration from the forced oscillation by impulse noise etc. will take place neither on the purpose frequency nor the frequency of the neighborhood, and the engine performance as LPF of each of said example is guaranteed.
[0042] Moreover, since the low inductance component 6 is a dissonance mold also in this case, the description of contributing to a productivity drive or cost reduction is the same as other examples.
[0043] In addition, it cannot be overemphasized that further improvement in the inhibition engine performance can be aimed at, without spoiling the description of the dissonance mold LPF by connecting the configuration of said example to a cascade, as shown in each example of drawing 4 (a), (b), and (c).
[0044]
[Effect of the Invention] Since according to the first means of this invention a parallel connection circuit with resistance equal to the imp value in the purpose frequency of a coil and a coil constitutes a high imp component and it is considering as the configuration of T characters or the L character mold LPF combining the low imp component, it is not based on external imp conditions, but an oppression ratio can be secured, and since it is a dissonance mold, sorting and adjustment of components become unnecessary, productivity is high and low cost-ization can be attained.
[0045] By setting up so that it may become lower enough than the purpose frequency from which a low imp component should be constituted only from a capacitor, and resonance frequency with the equivalence serial inductance of a high imp component should prevent the value according to the second means of this invention The frequency-conversion operation accompanying the shift to free vibration from the forced oscillation by impulse noise etc. is prevented, the engine performance as LPF of each of said example is guaranteed, and since it is a dissonance mold, sorting and adjustment of components become unnecessary, productivity is high and low cost-ization can be attained.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (a) The circuit diagram showing LPF of the first example of the first of this invention, and the second means
(b) The representative circuit schematic of LPF of the first example of the first of this invention, and the second means
[Drawing 2] (a) The circuit diagram showing LPF of the second example of the first of this invention, and the second means
(b) The representative circuit schematic of LPF of the second example of the first of this invention, and the second means
[Drawing 3] (a) The circuit diagram showing LPF of the third example of the first means of this invention
(b) The representative circuit schematic of LPF of the third example of the first means of this invention
[Drawing 4] (a) The circuit diagram of LPF in the case of aiming at improvement in the engine performance combining the first example of this invention
(b) The circuit diagram of LPF in the case of aiming at improvement in the engine performance combining each second example of this invention
(c) The circuit diagram of LPF in the case of aiming at improvement in the engine performance combining each third example of this invention
[Drawing 5] The block diagram showing the function of LPF in the conventional home automation system
[Drawing 6] (a) The circuit diagram showing LPF of the conventional T character mold
(b) The circuit diagram showing the L character mold LPF of the conventional noise source or the source side quantity impedance of a signal
(c) The circuit diagram showing the L character mold LPF of the conventional power-source line side quantity impedance
[Drawing 7] The impedance-characteristic Fig. of LC parallel resonant circuit in the component of conventional LPF
[Description of Notations]
1 Noise Source or Source of Signal
2 Noise-Source Impedance or Source Impedance
3 Power-Source Line Impedance
41, 42, 43, 47, 48, 49 Low pass filter (LPF)
5 Seven Quantity impedance component
6 Low Impedance Component
51 71 Coil
52 72 Resistance
61 Capacitor
51', 71' Equivalence serial impedance
52', 72' Equivalent series resistance
120 Power Line
130 Blocking Filter (BF)

140 Noise Filter (NF)
150 Controller
160 Adapter

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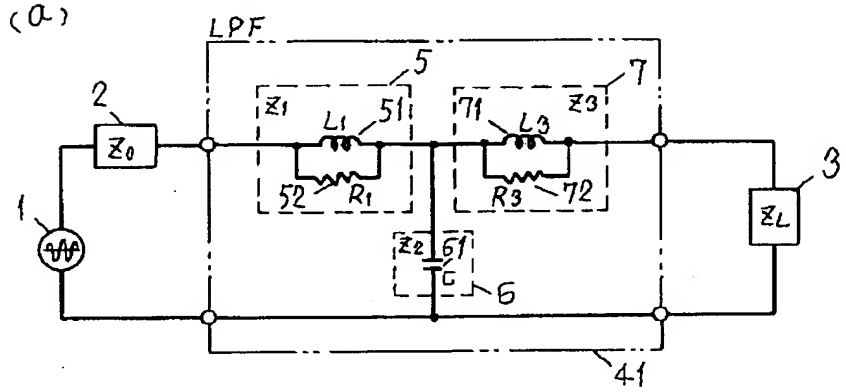
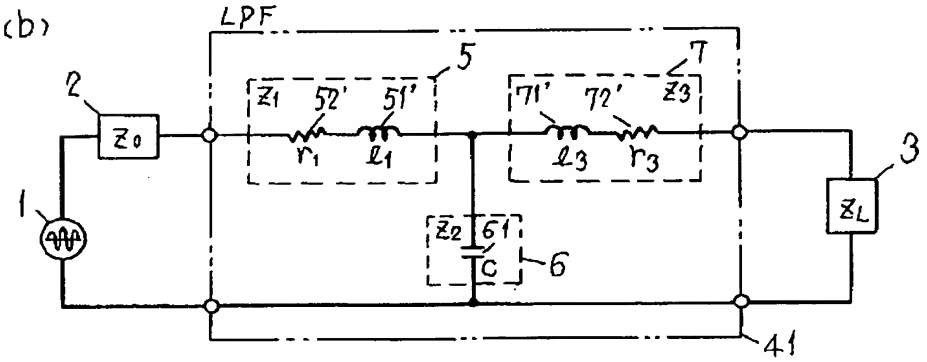
DRAWINGS

[Drawing 1]

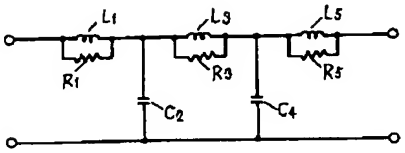
1---ノイズ源または信号源
2---ノイズ源インピーダンスまたは信号源インピーダンス
3---電源ラインインピーダンス
5,7---高imp素子
6---低imp素子
41---ローパスフィルタ
51,71---コイル
51',71'---等価直列インダクタンス
52,72---抵抗
52',72'---等価直列抵抗
61---コンデンサ





[Drawing 4]

(a)



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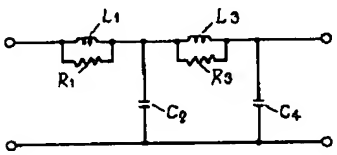

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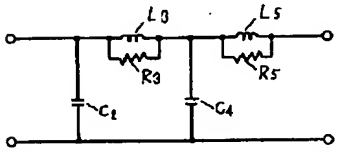
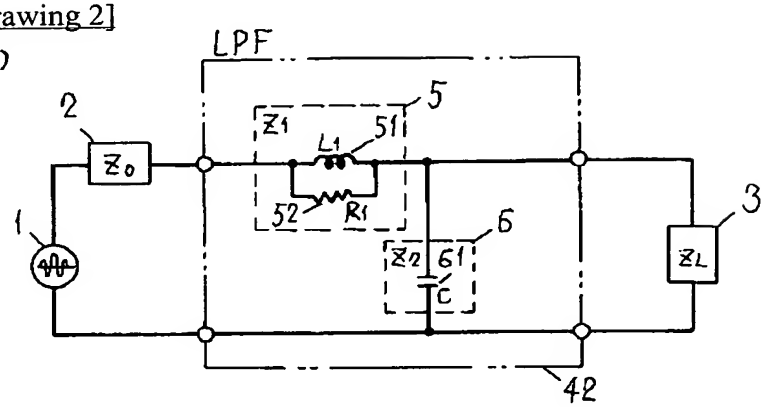


[Drawing 2]

(a)



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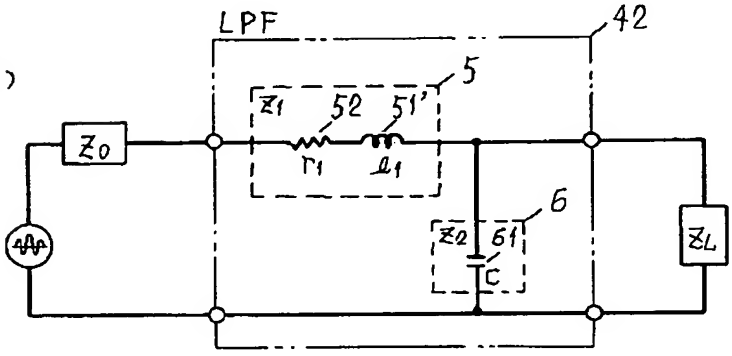

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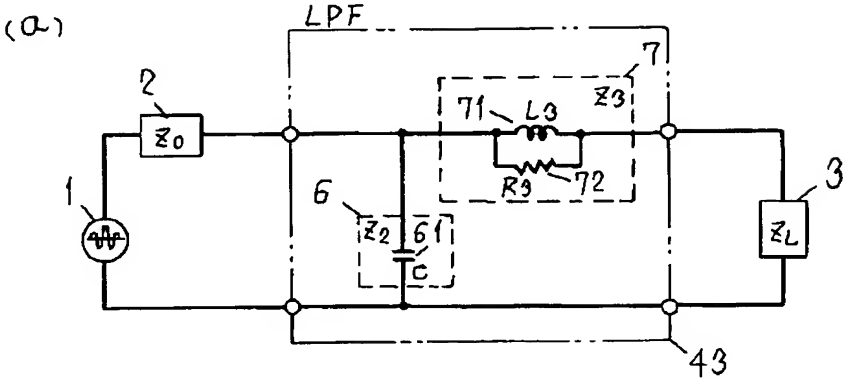

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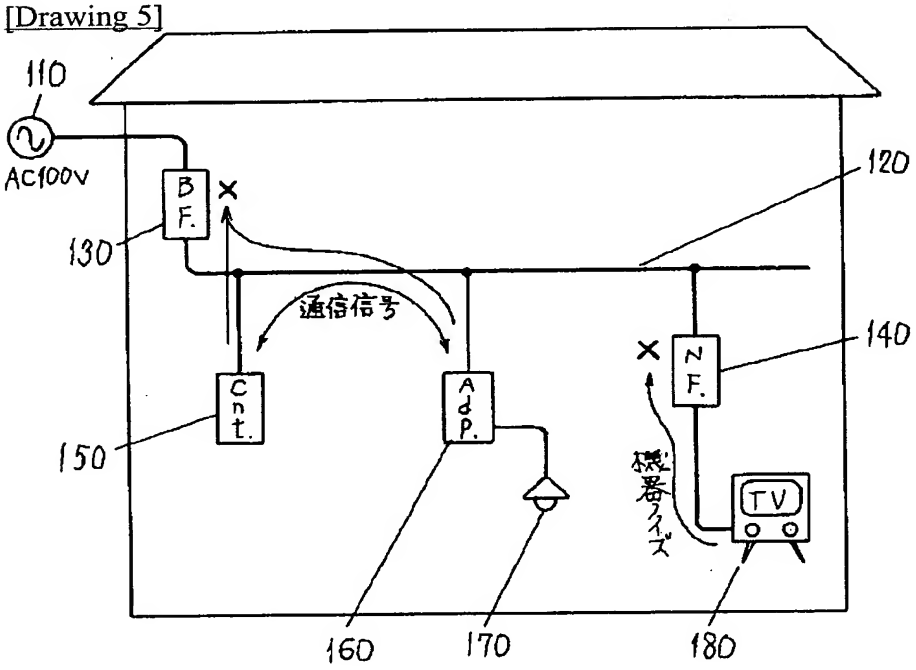

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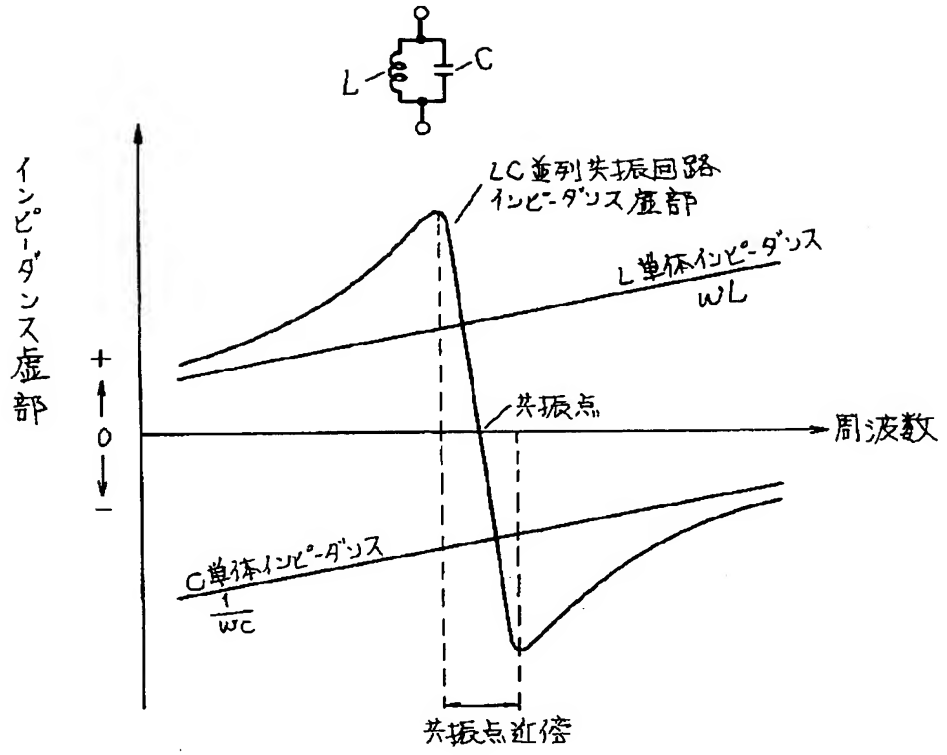
L
C
インピーダンス虚部
LC並列共振回路
インピーダンス虚部
L単体インピーダンス
ωL
+
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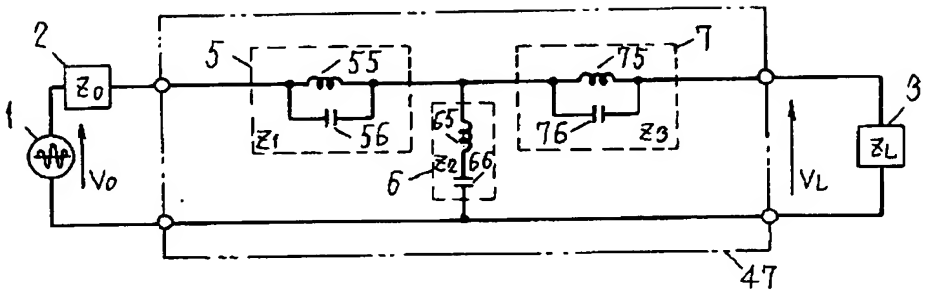
共振点
周波数
C単体インピーダンス
1/ωC
共振点近傍

[Drawing 6]

(a)



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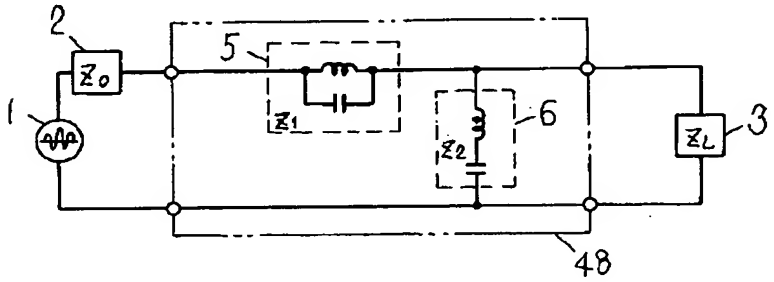

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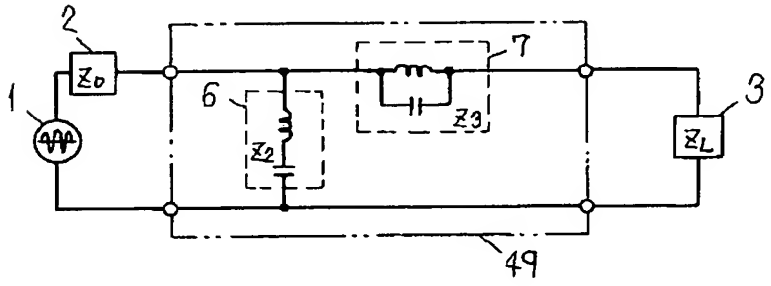

[Translation done.]

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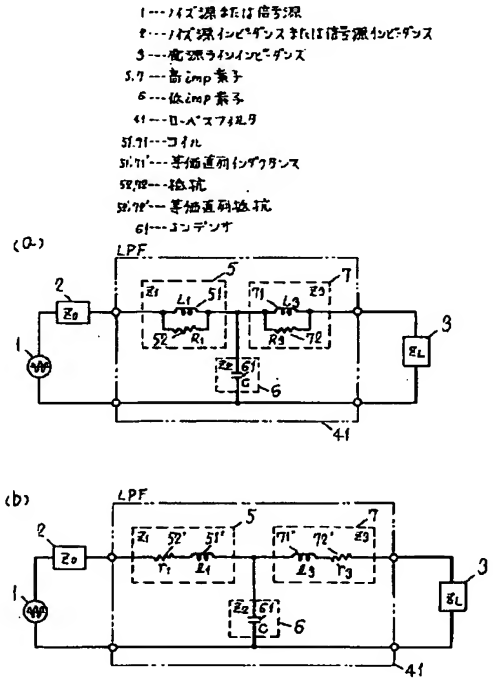
(54)【発明の名称】電力線搬送通信用ローパスフイルタ

(57)【要約】

【目的】　ホームオートメーション等の電力線搬送通信用に、一般には不定かつ変動する電力線やノイズ発生機器電源のインピーダンスとの整合を行うことなく充分な抑圧比を確保でき、インパルスノイズ等にも有効で、かつ、生産性が高く低コストのローパスフィルタの提供を目的とする。

【構成】　高ｉｍｐ素子５，７をコイル５１，５７と阻止すべき目的周波数におけるコイル５１，５７のｉｍｐに等しい抵抗５２，７２との並列接続回路で構成してｉｍｐ不整合であっても充分な等価直列抵抗分が残るようにし、低ｉｍｐ素子６を高ｉｍｐ素子５，７の各等価直列インダクタンスとの共振周波数が目的周波数より充分に低くなる容量のコンデンサ６１で構成して、インパルスノイズ等の妨害周波数への変換を防止し、全体を非共振回路の構成として共振のための部品の選別や調整を不要とし生産性の向上とコストの低減を実現する。



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【特許請求の範囲】

【請求項１】電源線の一方に直列に挿入された抑圧すべき目的周波数において高インピーダンスとなる一個または互いに直列接続された複数個の高インピーダンス素子と、高インピーダンス素子の一端または接続中点と電源線の他方との間に目的周波数において低インピーダンスとなる低インピーダンス素子とを有し、前記各高インピーダンス素子は、コイルと目的周波数における前記コイルのインピーダンス値に等しい抵抗値をもつ抵抗との並列接続回路で構成した、電力線搬送通信用ローパスフィルタ。

【請求項２】低インピーダンス素子をコンデンサのみで構成し、コンデンサの容量を、各高インピーダンス素子のコイルと抵抗とによる並列回路の各等価直列インダクタンス分とコンデンサとによる各々の共振周波数が、抑圧すべき目的周波数より充分に低い値となるように設定した、請求項１記載の電力線搬送通信用ローパスフィルタ。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、電力線を信号伝送路とし、高周波キャリアを用いて通信するホームオートメーション等の電力線搬送通信用ローパスフィルタに関するものである。

【０００２】

【従来の技術】電力線搬送通信方式によるホームオート＊

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＊メーションシステムでは、図５に示すように、ローパスフィルタ（以下ＬＰＦと略す）の用途は２種類ある。一つはコントローラ１５０とアダプタ１６０との間の通信信号の宅外漏洩を防ぐブロッキングフィルタ（以下ＢＦと略す）１３０であり、もう一つは電力線１２０に接続される家電製品等の機器ノイズを抑えるノイズフィルタ（以下ＮＦと略す）１４０である。

【０００３】これらのＬＰＦに共通の技術は、図６（ａ），（ｂ），（ｃ）に示すように、ＬＰＦ４７，４８，４９の内部素子５（Z_1），６（Z_2），７（Z_3）の各々が、阻止すべき目的周波数で共振するコイル５５，６５，７５とコンデンサ５６，６６，７６との並列または直列共振回路で構成されており、図６（ｃ）ではノイズ源側（左側）端子のノイズの目的周波数成分を抑圧して電源ライン側（右側）端子に出るのを防ぐと共に高インピーダンス素子７で電源ライン側のインピーダンス（以下ｉｍｐと略す）を高めるようになっており、図６（ｂ）では高インピーダンス素子５で信号源側（左側）端子のｉｍｐを高めると共に通信信号が電源ライン側（右側）に出るのを防ぐようになっており、図６（ａ）ではＴ字型の構成により電源ライン側ｉｍｐを高めると共にノイズの抑圧比を向上している。このとき信号またはノイズの抑圧比は

【０００４】

【数１】

$$\frac{V_L}{V_0}=\left|\frac{Z_2\,Z_L}{(Z_0+Z_1)(Z_2+Z_3+Z_1)+Z_2(Z_3+Z_L)}\right|$$

または、

$$\frac{V_L}{V_0}=\left|\frac{Z_2\,Z_1}{(Z_0+Z_1+Z_2)(Z_3+Z_L)+(Z_0+Z_1)Z_2}\right|$$

【０００５】で表される。

【０００６】

【発明が解決しようとする課題】一般に、電力線に接続される家電機器等の電源部の線間入力ｉｍｐは不特定かつ時間変動するので、電力線のラインｉｍｐ（Z_L）も不定となり、そこに挿入するＬＰＦとｉｍｐ整合を行うことは不可能である。

【０００７】また、図６の一般に磁芯入りコイルを用いて構成される高ｉｍｐ素子５および７には低周波数の大電流が流れるので、磁芯の磁気飽和によりコイルのインダクタンスが減少し共振点がずれてしまう。

【０００８】更に、図７に示すように、コイルとコンデンサとの並列共振回路は、入力周波数が共振周波数と同一であれば完全な抵抗性を示すが、共振点がずれてしまうと、共振点のごく近傍の周波数であっても、そのｉｍｐは、コイル単体より大きな誘導性からコンデンサ単体より小さな容量性まで、大幅な変化を示し、外部のあらゆるｉｍｐと簡単に直列共振してしまう。

【０００９】従って、共振点のずれた高ｉｍｐ素子５と信号源またはノイズ源ｉｍｐ２とが直列共振して微小抵抗分r_1のみ、また同様に、高ｉｍｐ素子７と電源ラインｉｍｐ３とが直列共振して微小抵抗分r_3のみしか各々残らなくなることもある。

【００１０】すると、前記抑圧比は

【００１１】

【数２】

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$$\frac{V_L}{V_0}=\left|\frac{Z_2\,Z_L}{Z_2(r_1+r_3)+r_1r_3}\right|\fallingdotseq\left|\frac{Z_L}{r_1+r_3}\right|$$

$$\left(\begin{array}{l}|Z_L|>1,\\ r_1\,r_2\ll 1\end{array}\Rightarrow\frac{V_L}{V_0}>1\right)$$

【００１２】となり、ＬＰＦとして無効であるばかりか有害ですらある。更に、低ｉｍｐ素子６は直列共振回路を構成しているために、インパルスノイズ等いかなる周波数であれ入ってきた高周波を強制振動によって蓄え、本来阻止すべき周波数に変換して、微小レベルではあるが自由振動によって放出するので、これもＬＰＦとしては好ましくない。

【００１３】また、コイルとコンデンサとによる共振回路の構成は、製造工程において部品の選別や共振点の調整を必要とし、生産性の低下やコストの上昇を招いていた。

【００１４】本発明は、外部のｉｍｐ条件によらず抑圧比を確保する生産性が高く低コストのＬＰＦを提供することを第一の目的とし、強制振動から自由振動に移行することによる周波数変換作用の起こらないＬＰＦを提供することを第二の目的としている。

【００１５】

【課題を解決するための手段】前記課題の解決のために、本発明の電力線搬送通信用ローパスフィルタは、第一の手段として、高ｉｍｐ素子をコイルとコイルの目的周波数におけるｉｍｐ値に等しい抵抗との並列接続回路によって構成することにより、第一の目的を達成し、更に第二の手段として、低ｉｍｐ素子を高ｉｍｐ素子の等価直列インダクタンスとの共振周波数が目的周波数より充分に低くなる容量のコンデンサとすることにより、第二の目的を達成するものである。

【００１６】

【作用】本発明の第一の手段によれば、高ｉｍｐ素子がコイルと抑圧すべき目的周波数におけるコイルのｉｍｐ値に等しい値の抵抗との並列接続回路は、

【００１７】

【数３】

$$R/\!/j\omega L=r+j\omega\ell\quad(\omega=2\pi f)$$

$$r=\frac{R(\omega L)^2}{R^2+(\omega L)^2},\quad \omega\ell=\frac{R^2\omega L}{R^2+(\omega L)^2}$$

【００１８】に従う並列直列変換により等価的に元の値の半分の値のインダクタンスと同じく半分の値の抵抗との直列回路となり、従来例で説明したような信号源またはノイズ源ｉｍｐや電源ラインｉｍｐによる直列共振によってインダクタンス分がなくなっても充分に大きな抵抗分が残るので、数２におけるr_1，r_3は微小ではなく低ｉｍｐ素子Z_2より充分に大きく電源ラインｉｍｐZ_Lと同等かそれより大きい値となるので抑圧比は

【００１９】

【数４】

$$\frac{V_L}{V_0}=\left|\frac{Z_2\,Z_L}{Z_2(r_1+r_3)+r_1r_3}\right|$$

$$(r_1,\ r_3\geqq|Z_L|\gg|Z_2|\Rightarrow\frac{V_L}{V_0}\ll 1)$$

【００２０】となり、充分な抑圧比が確保される。また、Z_1，Z_3は共振回路を構成していないので容量性となることは絶対に無く、従って、これらと直列共振を起こす外部ｉｍｐ条件はコンデンサのみとなり、直列共振の確率そのものが減少し、ますます充分な抑圧比が確保できると共に、従来必要としていた共振のための部品の選別や調整が不要となり、生産性の向上と低コスト化が図れる。

【００２１】第二の手段によれば、第一の手段の低ｉｍｐ素子Z_2をコンデンサのみで構成した非直列共振型であり、また、その容量値を、前後の高ｉｍｐ素子の等価直列インダクタンスとの共振周波数が抑圧すべき目的周波数より充分に低くなるように設定してあるので、強制振動から自由振動に移行することによる周波数変換作用は目的周波数やその付近の周波数では起こらず、ＬＰＦとしての性能が確保される。

【００２２】また、非共振型の回路構成となっているので、低ｉｍｐ素子を共振させるための部品の選別や調整作業が不要となり、生産性の向上やコストの低減が図れる。

【００２３】

【実施例】図１に本発明の第一の手段の第一の実施例を示す。

【００２４】図１（ａ）のＬＰＦは、電力線の一方に直列接続された二つの高ｉｍｐ素子５（Z_1）および７（Z_3）とその中点と電力線の他方との間に接続された低ｉｍｐ素子６（Z_2）とからなるＴ字型フィルタで、高ｉｍｐ素子５および７は各々コイル５１と抵抗５２およびコイル７１と抵抗７２との並列接続回路になっており、（数３）の変換式により図１（ｂ）のように並列直列変換される。

【００２５】ここで、このＬＰＦの性能が最低になる条件は、抑圧すべき目的周波数において等価直列インダクタンス５１’（l_1）および７１’（l_3）が各々信号源またはノイズ源ｉｍｐ２および電源ラインｉｍｐ３と各々直列共振した場合である。

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【００２６】このとき、$Z_o+Z_1=r_1$，$Z_3+Z_L=r_3$となり、抑圧比は（数４）で表される最低値をとる。

【００２７】例えば、一般に電力線搬送通信に使われる周波数１２５KHzでは、Z_L＝１０Ω程度であり、低ｉｍｐ素子６の構成は問わないものとしてZ_2＝０．２Ω，ωL_1＝４０Ω（角周波数$\omega=2\pi f$，）ωL_3＝４０Ω程度は容易に得られるので、R_1＝４０Ω，R_3＝４０Ωにすると、等価的に、r_1＝２０Ω，r_3＝２０Ωが確保でき、このときの抑圧比は最低約４６dBが保証される。

【００２８】また、このような高ｉｍｐ素子の構成では、共振型ではないので、コイルを流れる負荷電流によってインダクタンス値が多少変化してもＬＰＦの特性に大きな影響はない。例えば、インダクタンス値が半減しても全体の抑圧比は１dBの悪化にとどまることが確かめられている。従って、コイルや抵抗の厳密な選別や調整は不要であり、生産性の著しい向上とコストの低減とが可能となる。

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＊【００２９】図２に本発明の第一の手段の第二の実施例を示す。図２（ａ）のＬＰＦ４２は、電力線の一方に接続された高ｉｍｐ素子５（Z_1）と高ｉｍｐ素子５の電源ライン側と電力線の他方との間に接続された低ｉｍｐ素子６（Z_2）とからなる逆Ｌ字型フィルタで、高ｉｍｐ素子５はコイル５１（L_1）と抵抗５２（R_1）との並列接続回路になっており、通信信号が電源ライン側に漏れないようにするとともに信号源側のｉｍｐを高めるためのＢＦとして機能し、（数３）の変換式により図２（ｂ）のように並列直列変換される。この場合、ＬＰＦ４２は電源ライン側のｉｍｐを高める必要がないので、電源ラインｉｍｐ３と共振の恐れのある電源ライン側の高ｉｍｐ素子は削除している。

【００３０】動作原理は第一の手段の第一の実施例と同様で、その最低の抑圧比は

【００３１】

【数５】

$$\frac{V_L}{V_O}=\left|\frac{\dfrac{Z_2\,Z_L}{Z_2+Z_L}}{r_1+\dfrac{Z_2Z_L}{Z_2+Z_L}}\right|=\left|\frac{(Z_2/\!/Z_L)}{r_1+(Z_2/\!/Z_L)}\right|$$

$$\left(r_1\gg|Z_2/\!/Z_L|\Rightarrow\frac{V_L}{V_O}\ll1\right)$$

【００３２】に従う。例えば、Z_L＝約１０Ω，ωL_1＝４０Ω，R_1＝４０Ω，Z_2＝０．２Ωとすると、r_1＝２０Ωとなり、最低抑圧比は約４０dBが確保できる。

【００３３】また、電源ライン側の高ｉｍｐ素子がないので、小型化と低コスト化とが図れる。

【００３４】なお、非共振型であることによる他の特徴は第一の手段の第一の実施例と同様である。

【００３５】図３に本発明の第一の手段の第三の実施例を示す。図３（ａ）のＬＰＦ４３は、電力線の一方に接続された高ｉｍｐ素子７（Z_3）と高ｉｍｐ素子７のノイズ源側と電力線の他方との間に接続された低ｉｍｐ素子６（Z_2）とからなる逆Ｌ字型フィルタで、高ｉｍｐ素子７はコイル７１（L_3）と抵抗７２（R_3）との並列※接続回路になっており、電源ライン側のｉｍｐを高めると共に、ノイズ源ｉｍｐ２が充分に大きい場合にそのことを利用して、ノイズが電源ライン側に漏れないようにするＮＦとして機能し、（数３）の変換式により図３（ｂ）のように並列直列変換される。

【００３６】この場合、ＬＰＦ４３はノイズ源側のｉｍｐを高める必要がないので、ノイズ源ｉｍｐ２と共振する恐れのあるノイズ源側の高ｉｍｐ素子を削除している。

【００３７】動作原理は第一の手段の第一の実施例と同様で、その最低の抑圧比は

【００３８】

【数６】

$$\frac{V_L}{V_O}=\left|\frac{Z_2Z_L}{r_3(Z_O+Z_2)+Z_O\,Z_2}\right|$$

$$\left(r_3,\ Z_O\geqq Z_L\gg Z_2\Rightarrow\frac{V_L}{V_O}\fallingdotseq\left|\frac{Z_2\,Z_L}{Z_O\,r_3}\right|\ll1\right)$$

【００３９】に従う。例えば、Z_o＝約２０Ω，Z_L＝約１０Ω，ωL_3＝４０Ω，R_3＝４０Ω，Z_2＝０．２Ωとすると、r_3＝２０Ωとなり、最低抑圧比は約４６dBが確保できる。

【００４０】また、負荷側の高ｉｍｐ素子がないので、小型化と低コスト化とが図れる。なお、非共振型であることによる他の特徴は第一の手段の第一の実施例と同様である。

【００４１】更に、本発明の第二の手段の実施例として、図１，図２，図３の低ｉｍｐ素子を、各図にあらかじめ示しているように、コンデンサ６１のみの構成とすると共にその値を高ｉｍｐ素子５または７の等価直列イ

ンダクタンス５１または７１との共振周波数が抑圧すべき目的周波数より充分に低くなるように設定することにより、インパルスノイズ等による強制振動から自由振動への移行に伴う周波数変換作用は目的周波数やその付近の周波数では起こらなくなり、前記各実施例のＬＰＦとしての性能が保証される。

【００４２】また、この場合も低インダクタンス素子６は非共振型であるから、生産性向上やコスト低減に寄与するという特徴は他の実施例と同様である。

【００４３】なお、図４（ａ），（ｂ），（ｃ）の各実施例に示すように、前記実施例の構成をカスケードに接続することによって、非共振型ＬＰＦの特徴を損ねることなく更なる阻止性能向上が図れることは言うまでもない。

【００４４】

【発明の効果】本発明の第一の手段によれば、高ｉｍｐ素子をコイルとコイルの目的周波数におけるｉｍｐ値に等しい抵抗との並列接続回路によって構成し、低ｉｍｐ素子と組み合わせてＴ字またはＬ字型ＬＰＦの構成としているので、外部のｉｍｐ条件によらず抑圧比を確保でき、かつ非共振型なので部品の選別や調整が不要となり生産性が高く低コスト化が図れる。

【００４５】本発明の第二の手段によれば、低ｉｍｐ素子をコンデンサのみで構成し、かつその値を、高ｉｍｐ素子の等価直列インダクタンスとの共振周波数が阻止すべき目的周波数より充分に低くなるように設定することにより、インパルスノイズ等による強制振動から自由振動への移行に伴う周波数変換作用を防止し、前記各実施例のＬＰＦとしての性能が保証され、また、非共振型なので部品の選別や調整が不要となり生産性が高く低コスト化が図れる。

【図面の簡単な説明】

【図１】（ａ）本発明の第一および第二の手段の第一の実施例のＬＰＦを示す回路図

（ｂ）本発明の第一および第二の手段の第一の実施例のＬＰＦの等価回路図

【図２】（ａ）本発明の第一および第二の手段の第二の実施例のＬＰＦを示す回路図

（ｂ）本発明の第一および第二の手段の第二の実施例のＬＰＦの等価回路図

【図３】（ａ）本発明の第一の手段の第三の実施例のＬＰＦを示す回路図

（ｂ）本発明の第一の手段の第三の実施例のＬＰＦの等価回路図

【図４】（ａ）本発明の第一の実施例を組み合わせて性能向上を図る場合のＬＰＦの回路図

（ｂ）本発明の第二の各実施例を組み合わせて性能向上を図る場合のＬＰＦの回路図

（ｃ）本発明の第三の各実施例を組み合わせて性能向上を図る場合のＬＰＦの回路図

【図５】従来のホームオートメーションシステムにおけるＬＰＦの機能を示すブロック図

【図６】（ａ）従来のＴ字型のＬＰＦを示す回路図

（ｂ）従来のノイズ源または信号源側高インピーダンスのＬ字型ＬＰＦを示す回路図

（ｃ）従来の電源ライン側高インピーダンスのＬ字型ＬＰＦを示す回路図

【図７】従来のＬＰＦの構成要素中のＬＣ並列共振回路のインピーダンス特性図

【符号の説明】

１　ノイズ源または信号源

２　ノイズ源インピーダンスまたは信号源インピーダンス

３　電源ラインインピーダンス

４１，４２，４３，４７，４８，４９　ローパスフィルタ（ＬＰＦ）

５，７　高インピーダンス素子

６　低インピーダンス素子

５１，７１　コイル

５２，７２　抵抗

６１　コンデンサ

５１’，７１’　等価直列インピーダンス

５２’，７２’　等価直列抵抗

１２０　電力線

１３０　ブロッキングフィルタ（ＢＦ）

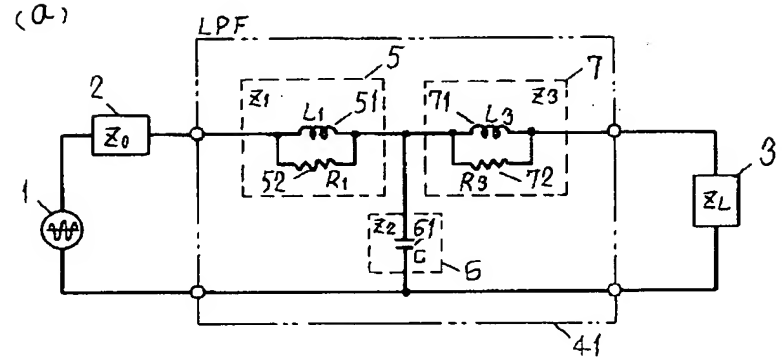
１４０　ノイズフィルタ（ＮＦ）

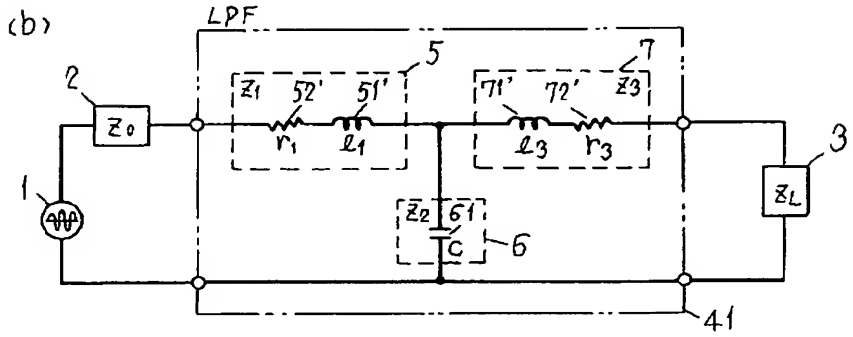
１５０　コントローラ

１６０　アダプタ

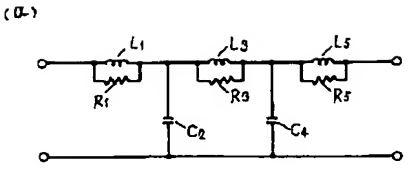
【図１】

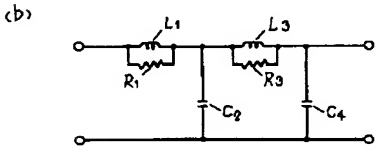
1---ノイズ源または信号源
2---ノイズ源インピーダンスまたは信号源インピーダンス
3---電源ラインインピーダンス
5,7---高imp素子
6---低imp素子
41---ローパスフィルタ
51,71---コイル
51',71'---等価直列インダクタンス
52,72---抵抗
52',72'---等価直列抵抗
61---コンデンサ

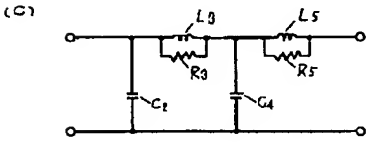




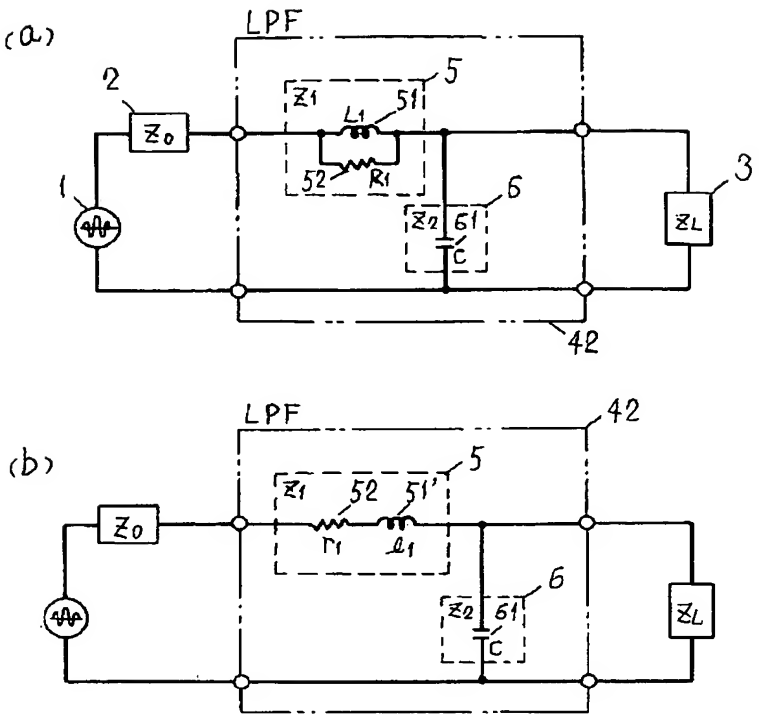
【図４】



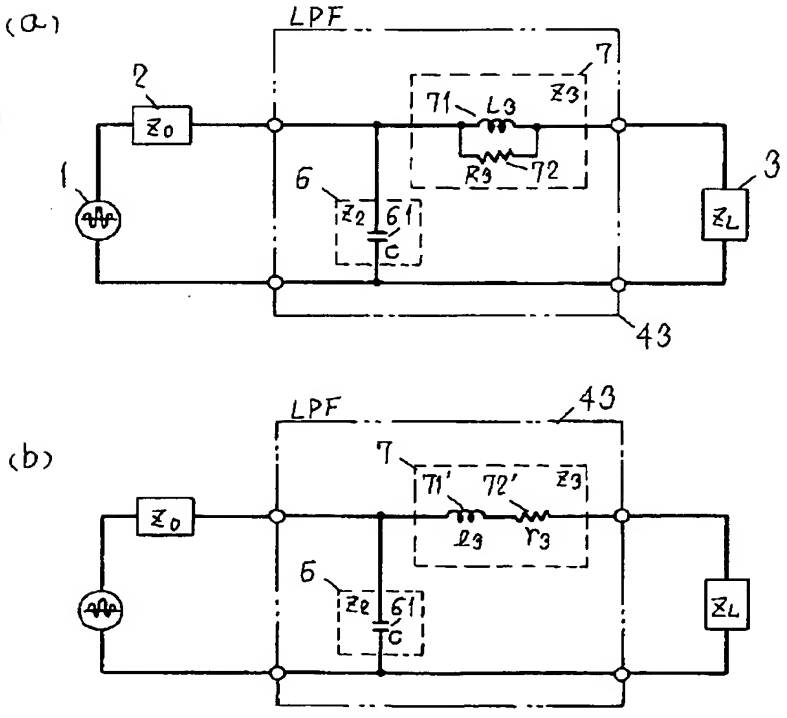




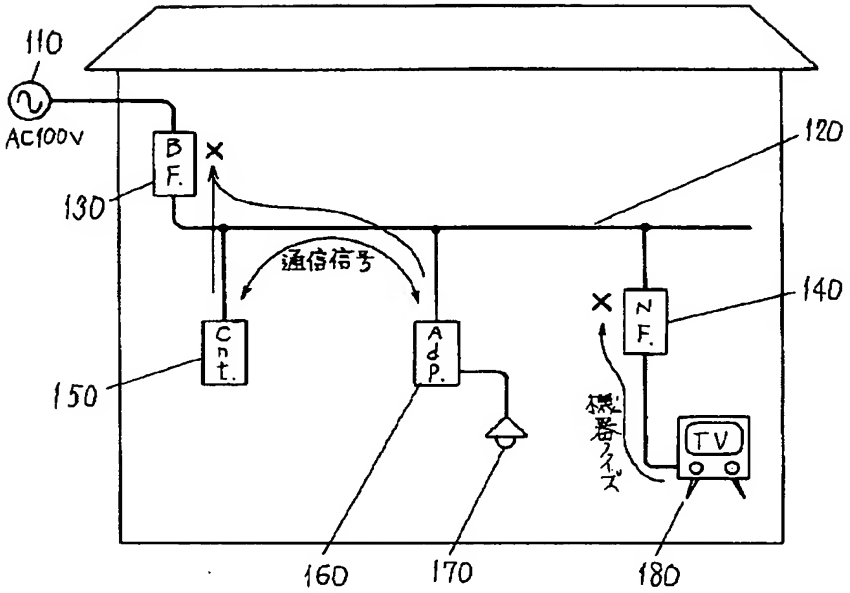
【図２】


(a)
LPF
2
Z0
Z1
L1
51
52
R1
5
6
Z2
61
C
1
3
ZL
42
(b)
LPF
42
Z1
52
51'
r1
l1
5
Z0
6
Z2
61
C
ZL

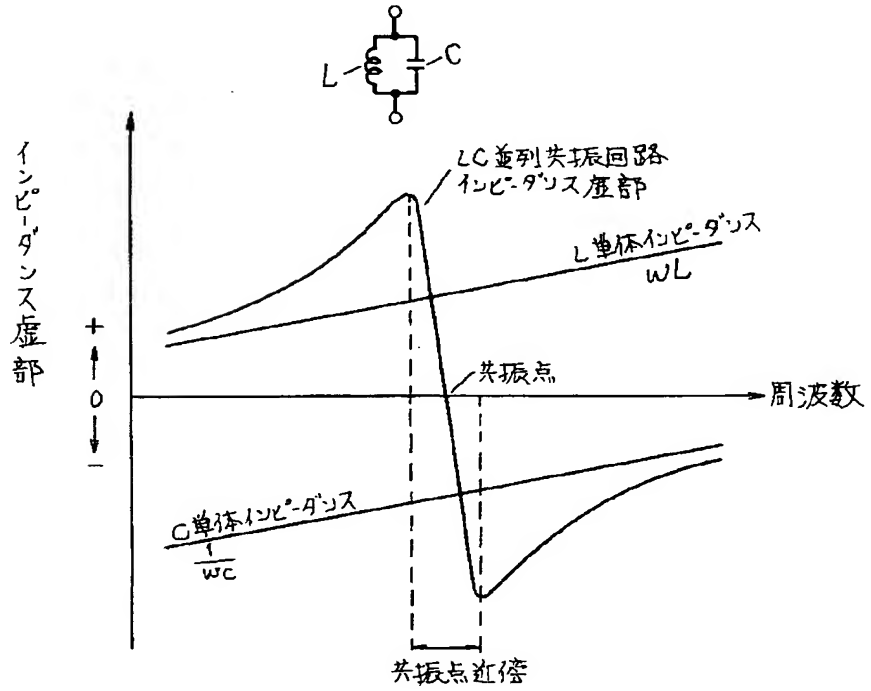
【図３】


(a)
LPF
2
Z0
7
Z3
71
L3
R3
72
1
6
Z2
61
C
3
ZL
43
(b)
LPF
43
7
Z3
71'
72'
l3
r3
Z0
6
Z2
61
C
ZL

【図５】

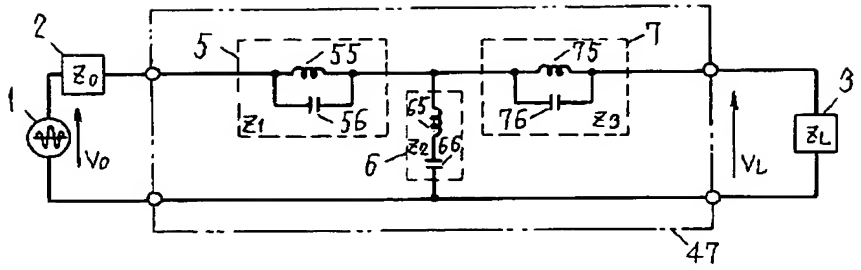

110
AC100V
B F.
130
120
通信信号
Cnt.
150
Adp.
N F.
140
機器クイズ
TV
160
170
180

【図７】

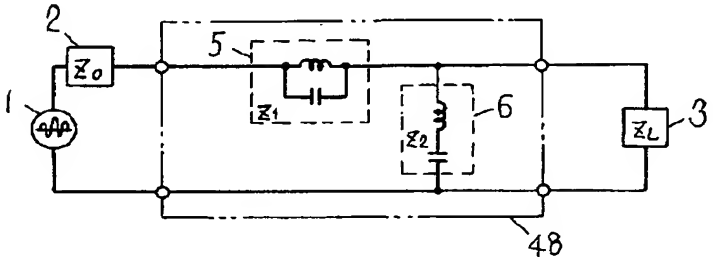

L
C
インピーダンス虚部
LC並列共振回路
インピーダンス虚部
L単体インピーダンス
ωL
共振点
周波数
+
0
−
C単体インピーダンス
1/ωC
共振点近傍

【図６】

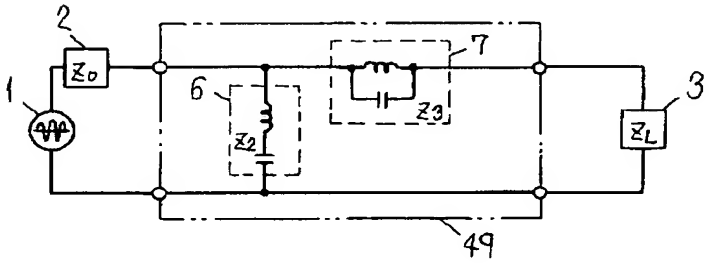
(a)


2
Z0
1
Vo
5
55
56
Z1
65
66
Z2
6
7
75
76
Z3
3
ZL
VL
47

(b)


2
Z0
1
5
Z1
6
Z2
3
ZL
48

(c)


2
Z0
1
6
Z2
7
Z3
3
ZL
49